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AN EXPERIMENTAL COMPARISON OF A CONVENTIONAL TV LESSON WITH A PROGRAMMED TV LESSON REQUIRING ACTIVE STUDENT RESPONSE.
STUDIES IN TELEVISED INSTRUCTION, REPORT 2.
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A SERIES OF EXPERIMENTS WAS CONDUCTED TO TEST THE EFFECTIVENESS OF TELEVISED INSTRUCTION. THIS REPORT, THE SECOND IN A SERIES, EXAMINED THE EFFECTIVENESS OF ACTIVE STUDENT RESPONSE ON LEARNING DURING TELEVISED LESSON. PRINCIPLES OF PROGRAMING DERIVED FROM TEACHING-MACHINE RESEARCH AND APPLIED IN THIS STUDY INCLUDED (1) THE REDUCTION OF LESSON CONTENT TO SMALL STEPS AND THEIR SEQUENCING, (2) THE ENCOURAGEMENT OF ACTIVE STUDENT RESPONSE AT EACH STEP, FOLLOWED BY KNOWLEDGE OF RESULTS OR REINFORCEMENT, AND (3) THE PRELIMINARY TRYOUT OF LESSONS TO DETERMINE THE PROBABILITY OF ACTIVE RESPONSES AT EACH STEP. TWO LESSONS, ONE ON THE EFFECT OF HEAT AND ONE IN NUCLEAR REACTIONS, WERE EMPLOYED. IN EACH, A PROGRAMED VERSION WAS CONTRASTED WITH A CONVENTIONAL LECTURE. RESULTS TENDED GENERALLY, BUT NOT INVARIABLY, TO SUPPORT THE EFFECTIVENESS OF ACTIVE STUDENT RESPONSE TO PROGRAMED MATERIAL. THE GAIN IN EFFECTIVENESS WAS GREATER FOR HIGH IQ STUDENTS THAN FOR LOW IQ STUDENTS. THIS SUGGESTED THAT PROGRAMED TELEVISION LESSONS DIRECTED TOWARD THE AVERAGE STUDENT IN A GROUP MAY BE INADEQUATE TO ELICIT CORRECT RESPONSES. THE RESULTS INDICATED THE DIFFICULTY OF PROGRAMING TELEVISION LESSONS FOR GROUP INSTRUCTION WHEN THERE ARE WIDE INDIVIDUAL DIFFERENCES IN ABILITY. RELATED REPORTS ARE ED 003 646 THROUGH ED 003 653. (HB)

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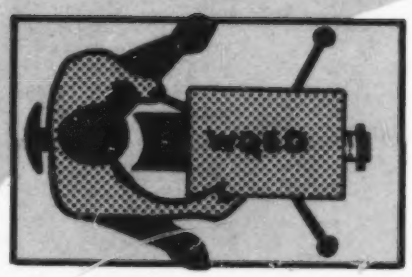
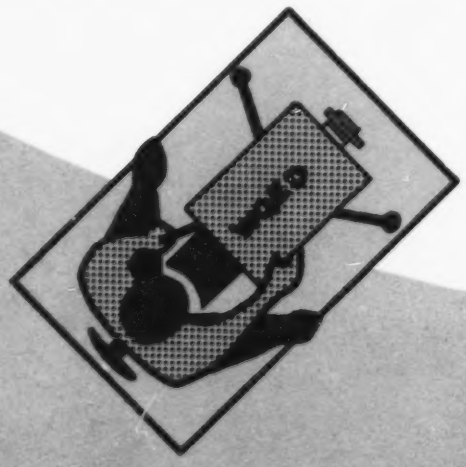


AN EXPERIMENTAL COMPARISON OF A CONVENTIONAL TV LESSON WITH A PROGRAMMED TV LESSON REQUIRING ACTIVE STUDENT RESPONSE



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PITTSBURGH, PENNSYLVANIA

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STUDIES IN TELEVISED INSTRUCTION

Report Number 2

AN EXPERIMENTAL COMPARISON OF A CONVENTIONAL TV LESSON WITH A PROGRAMMED TV LESSON REQUIRING ACTIVE STUDENT RESPONSE — —

Studies in Televised Instruction, Report 2.

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and

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Metropolitan Pittsburgh Educational Television Stations

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OVERVIEW

This is one of a series of reports on studies that use student responses to improve televised instruction. In these studies student response was used in three different ways. All three kinds of use shared the common objective of utilizing student responses to provide tangible, measurable indications of the adequacy of instructional procedures for attaining the educational goals of TV lessons.

1. USE OF STUDENT RESPONSE

...To Pre-test a TV Lesson

Student responses on an achievement test following a preview showing of a TV lesson were used as a basis for preparing a revised version of the lesson. Student performance on each test question indicated which points were fairly well learned and which points were not. This information provided useful feedback to the TV instructor, guiding him in the preparation of a more effective revision of his lesson.

2. USE OF STUDENT RESPONSE

...To Evaluate "Programming" Adequacy

...To Enhance Learning Effectiveness

"Programming" techniques derived from research on self-instructional devices were applied in the preparation of TV lessons. A primary purpose of these techniques was to facilitate correct responses by students. Procedures were designed to elicit active responding throughout the lesson. Students' ability to respond correctly provided evidence of how adequately the lesson sequences were programmed. Also, when students were encouraged to make frequent active responses to lessons programmed so they could respond correctly, the effectiveness of the lessons was significantly increased. Student responding was thus used first, to indicate the adequacy of lesson programming and second, to increase lesson effectiveness.

3. USE OF STUDENT RESPONSE

...To Evaluate Incentive Created by a TV Lesson

A TV lesson was designed to stimulate student follow-up activity. Students were encouraged to perform experiments at home that they had seen demonstrated on TV. Student responses in performing experiments at home on their own indicated the effectiveness of the TV lesson in providing an incentive for follow-up activity.

Much of the responsibility for attaining the instructional objectives of a TV lesson rests with TV teachers and producers. Student responses can be considered as the building blocks of the program. This means devising instructional procedures that will elicit appropriate responses, and judging these procedures as adequate only when students do, in fact, respond appropriately. This kind of careful and systematic attention to student responses should contribute strongly to the successful attainment of educational objectives.

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The report presented in this volume illustrates the dual use of student responses: to test programming adequacy and to enhance learning effectiveness.

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ABSTRACT

The primary purpose of this study was to demonstrate the effectiveness for learning of active student response during a televised lesson that has been "programmed." Principles of "programming" derived from teaching machine research and applied in this study include: (a) the reduction of lesson content into small steps and the logical sequencing of these steps; (b) the encouragement of active student response at each step, followed by knowledge of results (reinforcement); (c) the preliminary tryout of the lesson to determine the probability that the "programmed" lesson can elicit correct active responses at each step.

All three of these features are considered important for the effective control and guidance of student learning behavior. All three features are either absent or haphazardly present in conventional lecture methods on TV. The experimental comparison in this study was between a "programmed" lesson designed to improve and maximize control over learning behavior with a "conventional" TV lesson which provides minimal control.

Two lessons, one on "the effects of heat" and one on "nuclear reactions" were employed. In each case, a programmed version was contrasted with a conventional lecture.

Results tend generally, but not invariably, to support the effectiveness for learning of active student response to "programmed" material. The gain in effectiveness was, in general, greater for high IQ students than for low IQ students. This was interpreted to mean that "programmed" TV lessons directed toward the average student in a group, may be inadequate to elicit correct responses from below average students. The results tend to highlight the difficulty of programming TV lessons for group instruction when there are wide individual differences in ability.

INTRODUCTION

A tutor teaching an individual student has the opportunity to maintain control over his student's learning behavior. He can stimulate the student to respond, he can provide an appropriate context in which the student is to respond, and he can reinforce or reward the student when he makes correct responses. These are features of instruction considered by many investigators essential for the systematic control of learning behavior. In the classroom, on the other hand, the teacher who provides instruction for large groups of students is not likely to be able to maintain optimal control over all these factors for all students (7).

Televised instruction by the conventional lecture method has in the past not even afforded the opportunity for the partial degree of control that the classroom teacher can exercise. There has been no opportunity in conventional TV instruction for student-teacher interaction. Thus, no opportunity has generally been provided the instructor to encourage students to rehearse responses, to prepare them with adequate cues to respond correctly, or to provide them with feedback about the correctness of their responses.

These features of systematic control of learning behavior represent the core of instruction by teaching machines (2 & 3). In the use of teaching machines, the efficiency of student learning behavior is further maximized by gearing the rate of presentation to suit individual needs. The individual student is allowed to select his own pace, increasing the probability of his responses being correct. This capability for self-pacing by the individual student is most clearly absent in both film and TV instruction. Instruction by both media proceeds at a fixed pace tending to result in less adequate matching of rate of presentation and student abilities. The mismatch leads to lower probabilities of correct student response at each learning step. The result is thus likely to be less than optimum control of the learning behavior of all students with the corollary of generally lowered student achievement.

The fixed-pace nature of film and TV instruction does not, however, completely preclude features of instruction that constitute what we mean by control

or guidance of student learning behavior. There is a considerable body of film research, for example, that demonstrates the effectiveness of active student response during the course of fixed-pace instruction. Much of this film research on active student participation has been reviewed in detail elsewhere (1, 2, & 6). Initial applications of audience participation to TV have also been described in a study of military training (3). The general findings of several studies indicate that active participation or the practice of responses to be acquired can lead to superior learning and retention as compared with passive viewing and listening to lesson material.

In this study it was proposed to test the effectiveness of active student response during televised instruction. To do so, an experimental comparison was made of a lesson that encourages and prepares students to make active responses with one that does not.

In the teaching-machine field, a lesson which prepares a student to be able to respond correctly is said to be "programmed." Programming generally consists of: (a) the reduction of lesson content into small steps; (b) the careful sequencing of these steps; and (c) the inclusion within each segment or step of cues strong enough to elicit correct active responses. The primary aim of these programming procedures is to guide and control student learning behavior systematically.

The experimental lesson used in this study was a "programmed" one, in the teaching-machine sense, which thus attempted to provide for a considerable degree of control over the learning behavior of groups of students. It was compared with a "conventional" TV lesson which, ordinarily maintains less systematic control over learning behavior.

METHOD

An experimental comparison was made to determine the relative effectiveness of a "conventional" TV lesson and an experimental TV lesson that used sequenced or "programmed" material and encouraged active student response. The experimental comparison was replicated using two different lessons, one on the "effects of heat" and one on "nuclear reactions." Both lessons were integral parts of an entire Junior High School science series presented throughout the school year by Metropolitan Pittsburgh Educational Television Stations (WQED-WQEX).

Preparation of the "conventional" TV lesson

For each of the two different lessons, a competent Junior High School science teacher undertook the task of preparing a statement of lesson objectives. To be able to do this effectively, he became familiar with the entire series of instructional half hours, with what preceded each lesson, and with what was to follow. Based on this familiarization and a careful delineation of how the lesson was to fit in with the entire series, he then prepared a statement of lesson objectives. This consisted of the identification of the facts students were expected to learn and concepts they were expected to understand.

Then with the collaboration of a television director, the teacher prepared a lesson that sought to meet these objectives. The script, the visual aids, the demonstrations, and the stage directions were developed and, following studio rehearsal, the "conventional" lesson was recorded. (The scripts for the "conventional" lessons on "heat" and on "nuclear reactions" appear in Appendix A.) (It will be noted that the script for the lesson on "heat" is the same as the revised, improved script described in Report No. 1 in this series.)

Preparation of the programmed TV lesson

At the same time that a teacher was preparing a standard or "conventional" script for each of the two lessons, the research staff, working from the same set of lesson objectives, was preparing a second version of the lesson. This was the experimental version. It provided students the opportunity to respond actively throughout the entire lesson. Some of the responses they were to make were merely "covert" ones; that is, they could think of the answers or say them

to themselves. Other responses called for were "overt," consisting of written answers on work sheets prepared for the purpose (see Appendix B).

The following is a sample work sheet item for the lesson on nuclear reactions.

> Atoms recombine in chemical reactions to
> form new _ _ _ _ _ _ _ _ _s.

The item corresponds to the identical sentence to be flashed on the screen during the telecast of the lesson. Based on their prior preparation, students were expected to fill in the blank with the word "molecules."

The lesson had been prepared or programmed in such a way as to insure a high probability that students would make a correct response, that is, in this case writing the word "molecules" in the blank space. What were the techniques for insuring this high probability? First, to prepare a known basis of student understanding of prior concepts, the lesson just preceding the lesson on nuclear reactions was also prepared by the research staff. With reasonable assurance that students would understand the necessary prior concepts, the lesson on nuclear reactions itself was then prepared or programmed. Its preparation attempted to maximize the orderly and logical arrangement of facts and concepts. The material was divided into small steps with the mastery of each step judged necessary for the mastery of the next. The mastery of a step was made highly probable by providing sufficient prompts or cues at the outset. The strength of the prompts and cues were, in general, varied throughout the sequence of steps. Starting with strong cues and gradually reducing them as students became more able to respond with less need for prompting, the strength of the cues provided was that judged sufficient at each step.

Empirical evidence was also obtained to determine whether students could, in fact, make correct responses at each step in the lesson by trying out the script (minus the visuals) with three students prior to its presentation and recording on film. An empirical tryout of the lesson on-the-air under conditions similar to those prevailing during its ultimate use would have provided even better evidence of its adequacy. An on-the-air tryout would not only have had the benefit of the visual presentations, but would also have shared some of the disadvantages (such as a less flexible rate of presentation). The "live"

tryout did, nevertheless, serve the purpose of indicating whether a small group of students could respond correctly to a verbal presentation that approximated the ultimate fixed-pace presentation. Revisions were made whenever students were unable to respond in the tryout. The final revised version was the one presented on-the-air during the experiment.

In the presentation of the "programmed" lesson the lecturer paused just prior to the expected responses to allow students sufficient time to complete statements he had begun. In addition, a question mark flashed on the screen accompanying the pause (see Figure 1).

Figure 1

Both pauses and question marks were intended to encourage students to make active responses. Following the pause, the TV instructor would then complete statements he had began, giving students "feedback" as to whether or not their own responses

were correct. (The exact instructions to students on how to respond appear at the beginning of the script for the experimental version of lessons in Appendix A.)

Instruction time in experimental and control versions was equated; both versions lasted approximately twenty-four and one-half minutes. The amount of time in each of the two versions of the lesson devoted to the same point or item of information, of necessity, varied. The criticism might be raised that unequal emphasis was thus placed on lesson points by the two versions of the lesson. In reply it need only be pointed out that in part, at least, it is the effect of this difference which the experiment primarily seeks to evalute. The experimental comparison centers on the contrasting effectiveness of a systematic method for preparing lesson content (i.e., the programming of learning sequences) with conventional, presumably less systematic methods. The goal of the programmed lesson was to prepare students to be able to make correct responses. To achieve this goal, judgments were made as to relative amount of emphasis needed at each step in the lesson. Furthermore, empirical tryouts provided the evidence necessary to confirm or reject these judgments. The conventional presentation neither requires active student response nor allocates time and emphasis to achieve it. The purpose of the present experiment, thus, was to make an over-all comparison of these two different approaches; the use of active response was here a deliberate part of the attempt to employ the sequencing and allocation emphasis necessary to allow students to respond <u>correctly</u>.

Procedure

On the day the lesson on "nuclear reactions" was regularly scheduled to be shown, both versions of the lesson, which had already been recorded, were telecast simultaneously. The experimental (programmed) version was shown on Channel 16 (UHF); the control (conventional) version was shown on another channel, Channel 13 (VHF).

Six classes at the seventh and eighth grade levels with a total of 158 students were selected from the population of classes which regularly watched the science series. Students within each class were paired off in advance on the basis of sex and intelligence, and one member of each pair was randomly assigned to one of two rooms. The group in one room watched the experimental version

over one channel; the other group, in a different room, watched the control version presented on the second channel. The random assignment of the members of pairs of students from each class to experimental or control groups meant that the performance of individuals rather than intact classes provided the units for observation. (Statistical analysis of data could thus be properly based on degrees of freedom deriving from the number of students in the sample rather than merely from the number of classes, as would be required had intact classes been assigned to treatments in toto.)

This was the procedure followed when the experimental comparison was based on the lesson on "nuclear reactions." The same procedure was followed in the replicated experimental comparison based on the lesson on "heat." Here, however, students were instructed to make their responses "out loud" rather than to say the answers to themselves. Another difference was the size of the sample, in this case three matched classes with a total of 140 cases.

Data

Data consisted of scores obtained from achievement tests administered after the telecast.[1] One test was administered either the same or the next day as a measure of acquisition. A delayed test was also administered approximately a week and a half to two weeks following the telecast, as a measure of retention. The tests were designed to cover stated objectives which were identical for both control and experimental versions of the lesson. Tests administered to experimental and control groups were, of course, identical (see Appendix B).

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[1] A pre-test had been administered to a sample class before the lesson was shown on-the-air. This served two purposes: (a) to provide a measure of the amount of prior knowledge students had; and (b) to aid in the preparation of the achievement test to be used in the experiment proper.

RESULTS

Achievement test data were analyzed to compare the relative effectiveness of the programmed (experimental) versions and the "conventional" lecture (control) versions of the lessons on "heat" and on "nuclear reactions."

Experiment No. 1:

Lesson on the "Effects of Heat"

Immediate post-test

On a 40-point test administered either immediately following the telecast or the next day (at the administrative convenience of the schools) students who watched the experimental version of the lesson on the "effects of heat" received higher test scores than did their control counterparts. The entire experimental group averaged 2.6 points or seven percent higher than the control group. The difference, although not large, was statistically significant. The magnitude of the difference, it appears, was affected by combining the results for high IQ and low IQ students; for high IQ students profited considerably from the experimental version while low IQ students did not profit significantly.

Analysis of the interaction of IQ[2] and test performance revealed the differential effect of the experimental version on high and low IQ students. The high IQ students who were encouraged to make active responses to the experimental version of the lesson averaged 12 percent (or 4.9 points) higher on the achievement test than did students with equally high IQ's who watched the control version of the lesson. This result was statistically significant. The difference between experimental and control groups for low IQ students, however, was only 0.2 points (a nonsignificant finding).

Table 1 below summarizes the results from the analysis of variance for the immediate post-test scores.[3]

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[2] For purposes of analysis, each class was divided in half with one half falling above, the other below the median IQ for the class.

[3] Correction was made for unequal cell frequencies.

Table 1

Analysis of Variance for
Immediate Post-Test
(Heat Lesson)

	Mean Square	D.F.	F	P
Methods	179.6	1	5.01	.05*
IQ	1533.9	1	42.78	.001***
Schools	856.4	2	23.87	.001***
Methods x IQ	157.1	1	4.38	.05*
Methods x Schools	60.0	2	1.67	—
Schools x IQ	184.1	2	5.13	.05*
Methods x IQ x Schools	159.9	2	4.46	.05*
Within[+]	35.86	128	—	—

		Mean Achievement Scores	S.D.	
1)	Experimental Group	25.6	7.4	
	Control Group	23.0	4.8	
	Difference	2.6		
2a)	High IQ Experimental Sub-Group	30.5	3.2	t = 2.36
	High IQ Control Sub-Group	25.6	3.9	D.F. = 32
	Difference	4.9		P = .02[++]
2b)	Low IQ Experimental Sub-Group	20.6	7.6	t = .22
	Low IQ Control Sub-Group	20.4	4.3	D.F. = 36
	Difference	0.2		P = .80

*significance at the 5 percent level

***significance at the .1 percent level

[+]The second order interaction was not used as the error term since its use depends on the assumption that the categories for one or more of the variables be regarded as a random selection from the population being sampled. That assumption was not met here.

[++]significance between the 5 and 1 percent level

Delayed post-test

A test of student retention was administered approximately a week and a half to two weeks after the telecast of the lesson. Table 2 summarizes the over-all analysis of results for the test of retention.

Table 2

Analysis of Variance for
Delayed Test
(Heat Lesson)

	Mean Square	D.F.	F	P
Methods	1.0	1	.02	—
IQ	605.0	1	10.30	.01**
Schools	649.5	3	11.04	.001***
Methods x IQ	376.7	1	6.40	.05*
Methods x Schools	7.0	3	.12	—
IQ x Schools	58.5	3	.99	—
Methods x IQ x Schools	143.2	3	2.43	—
Within	58.8	128	—	—

		Mean Achievement Scores	S.D.	
1)	High IQ Experimental Sub-Group	26.0	2.4	t = 2.52
	High IQ Control Sub-Group	22.1	4.7	D.F. = 30
	Difference	3.9		P = .02+
2)	Low IQ Experimental Sub-Group	16.7	5.2	t = 3.14
	Low IQ Control Sub-Group	21.0	4.8	D.F. = 38
	Difference	-4.3		P = .01**

*significance at the 5 percent level

**significance at the 1 percent level

***significance at the .1 percent level

+significance between the 5 and 1 percent level

The superiority of the experimental version found in the immediate post-test to be primarily associated with the high IQ group was also present in the delayed post-test. A significant difference in test scores was found between the high IQ experimental group and the high IQ control group. The former averaged 26.0 on a 40-point test; the latter averaged 22.1 on the same test. A significant difference in favor of the control group, however, was found on the retention test among low IQ students; (21.0 for the control and 16.7 for the experimental group).

It has been often suggested that to be effective, elicited active responses should be correct ones. If incorrect responses are elicited, they may become fixated. It may be speculated that the benefit of active response primarily for the high IQ students (specifically in the test of retention) in this study is the result of the problems inherent in programming fixed-pace materials for large groups of students. The programming or sequencing of material in fixed-pace presentation to a group, members of which vary widely in age and ability, must be directed at allowing the average student to make correct responses. In aiming at the average student, the resulting lesson may be easily mastered by high IQ students, but be inadequate for low IQ students. This may have the consequence that low IQ students make incorrect responses, ultimately resulting (even though the errors were corrected almost at once when the instructor supplied the correct answer) in poorer performance on the achievement tests than the low IQ students who watched the control version (conventional lecture). (A correlation was computed between IQ and the number of correct responses made on active response work sheets; this was found to be .78, suggesting that the program more adequately prepared the bright students than it did the below average students.) The results reported here favoring this interpretation highlight the difficulty in trying to maintain control over the learning behavior of groups of students exposed to a fixed-pace lesson.

Experiment No. 2:

Lesson on "Nuclear Reactions"

Results were analyzed separately for two forms of an achievement test (A & B) administered at three different times. Students in one group of schools,

on a random basis, took either Form A or Form B of the test immediately after the telecast. Whichever form they took, A or B, approximately two weeks later, they took the alternative form of the test. Students from a second group of schools took either Form A or Form B of the test the day following the telecast. The three different testing times, the same or next day and two weeks later, thus provide both a measure of acquisition and a measure of retention.

Since students assigned to experimental and control groups were matched for IQ, in the analyses that follow a residual error term was used whenever possible instead of the within groups variance to take advantage of the possible reduction in variance associated with the matching variable. High and low IQ's were grouped to permit use of the residual error term whenever preliminary analyses indicated that there were no significant IQ and method interactions.[4]

Test administered immediately after the telecast

For Experiment No. 2, no consistent differences were found on this test between experimental (active response) and control (conventional lecture) groups. On Form A of the test (42 possible points) the experimental group had a mean score of 10.4 and the control group 8.1. The difference was ~~now~~ not, however, statistically significant. The results are summarized in Table 3.

Table 3

Analysis of Variance for Form A Administered
on the Same Day as the Telecast
(Nuclear Reactions Lesson)

	Mean Square	D.F.	F	P
Methods	54.15	1	2.42	—
Schools	42.15	2	1.88	—
Methods x Schools	33.89	2	1.51	—
Within[++]	22.4	40	—	—

	Mean Achievement Scores
Experimental	10.4
Control	8.1

[++]The within variance was smaller than the variance associated with the matching variable, and therefore a residual error term could not be computed.

[4]In the analysis of the results for the lesson on "heat" reported in the first section, the methods x IQ interaction was significant, and therefore IQ categories were not grouped, and a residual error term was not used.

On Form B of the test administered the same day, the experimental groups in two of three schools averaged higher than their matched control counterparts. Results of the analysis of variance summarized in Table 4 show a significant interaction between method of presentation and schools.

Table 4

Analysis of Variance for Form B Administered on the Same Day as the Telecast (Nuclear Reactions Lesson)

	Mean Square	D.F.	F	P
Methods	.53	1	.16	—
Schools	23.19	2	6.92	.01**
Method x Schools	33.25	2	9.92	.01**
Residual (error)	3.35	16	—	—

	Mean Achievement Scores
Experimental	10.0
Control	10.8

**significance at the 1 percent level

Test administered the day after the telecast

A similar significant interaction of method and schools was found for Form A administered on the day following the telecast. Once again, for two out of three schools only, did the performance of the experimental group surpass that of the control group. The schools represented here were not the same as those which took the test on the same day as the telecast. But, here the over-all comparison of experimental and control groups showed a significant difference in favor of the experimental group. The average for the experimental group was 16.5 and for the control group it was 12.9. Results of the analysis of variance are summarized in Table 5.

Table 5

Analysis of Variance for Form A Administered
the Day After the Telecast
(Nuclear Reactions Lesson)

	Mean Square	D.F.	F	P
Methods	131.65	1	14.17	.01**
Schools	181.30	2	19.52	.001***
Methods x Schools	134.76	2	14.51	.001***
Residual (error)	9.29	16	—	—

	Mean Achievement Scores	S.D.
Experimental	16.5	3.8
Control	12.9	4.0

**significance at the 1 percent level
***significance at the .1 percent level

On the alternate Form B similarly administered the day following the telecast, there were no significant differences, although the average for the experimental group exceeded that of the control group, 11.4 to 10.9. Table 6 summarizes the analysis of variance for these results.

Table 6

Analysis of Variance for Form B Administered
the Day After the Telecast
(Nuclear Reactions Lesson)

	Mean Square	D.F.	F	P
Methods	3.43	1	.20	—
Schools	59.60	2	3.39	—
Methods x Schools	1.50	2	.09	—
Residual (error)	17.56	16	—	—

	Mean Achievement Scores
Experimental	11.4
Control	10.9

Test administered two weeks after the telecast

On a test of retention administered approximately two weeks after the telecast, the experimental group (active response) received higher scores on both forms of the test. For only Form B of the test, however, did this difference reach statistical significance. Here the average of the experimental group was 9.3 to 6.8 for the control group. Tables 7 and 8 summarize the results for the test of retention.

Table 7

Analysis of Variance for
Form A Delayed Test
(Nuclear Reactions Lesson)

	Mean Square	D.F.	F	P
Methods	7.40	1	.15	—
Schools	71.69	2	1.48	—
Methods x Schools	17.90	2	.37	—
Within	48.6	28	—	—

	Mean Achievement Scores
Experimental	12.2
Control	11.2

Table 8

Analysis of Variance for
Form B Delayed Test
(Nuclear Reactions Lesson)

	Mean Square	D.F.	F	P
Methods	61.89	1	7.41	.05*
Schools	13.08	2	1.57	—
Methods x Schools	17.55	2	2.10	—
Residual (error)	8.35	15	—	—

	Mean Achievement Scores	S.D.
Experimental	9.3	0.9
Control	6.8	1.6

*significance at the 5 percent level

In five out of six comparisons based on alternative forms of a test administered at three different times following the telecast of the lesson on nuclear changes, the mean performance for the experimental (active response) group exceeded that of the control group (conventional lecture). Two of the five comparisons were statistically significant with a third significant for some of the schools in the sample. Of the significant over-all comparisons, one was a test of acquisition; the other of retention.

Although these results are inconsistent, there is some evidence derived from the lesson on "nuclear reactions" indicating the effectiveness of active response. Taken together with the consistent and significant positive findings based on the lesson on the "effects of heat," they jointly tend to lend some support to the value of active response for learning and retention and would suggest that active student response elicited by a TV lesson that is sequenced or programmed appears to contribute to better student learning and retention than a "conventional" TV lecture can produce. The results of Experiment No. 1 (Table 2), however, suggest that for this gain to be effective among students of below average ability, care must be taken to insure that they can respond <u>correctly</u> during the TV lesson; otherwise, the active-response procedure may "backfire" for the lower ability students. As more is learned about programming techniques for group instruction, more effective accommodation of individual differences should be possible.

DISCUSSION

In the first study in this series (1) a significant improvement in a conventional TV lesson on the "effects of heat" was reported. The improvement as measured by student achievement was brought about through a process of lesson tryout and revision. Results of an achievement test administered after a preview showing of a lesson were used to indicate which parts of the lesson were in need of revision or improvement. An experimental comparison of the resulting revised version and the preview version of the lesson revealed the superiority of the revised version. Students who watched the revised version of the lesson on "heat" averaged higher on achievement tests than did students who watched the preview version.

The results of the experiment reported here, in which the revised version of the lesson on "heat" was now used as the control version, reveal that still further improvements could be made. The experimental version that was systematically programmed or sequenced and in which students were stimulated to make active responses, now proved superior to the control version (the improved version from Experiment No. 1). To what is this further improvement attributable?

Acquisition of academic knowledge presumably derives from the making of verbal responses (whether covert or overt) in the presence of appropriate cues, and from reinforcement of those responses. For example, an instructor may expose the student to the following incomplete sentence.

> Atoms recombine in chemical reactions
> to form new _ _ _ _ _ _ _ _ _ s.

The student with sufficient prior preparation is expected to, and does make the verbal response "molecules" either to himself, out loud, or on paper. The instructor, after a suitable pause, then informs students that "molecules" is correct. Feedback of results constitutes the "reinforcement."[5]

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[5]However, since it also makes possible further (and/or corrected) rehearsal of the response, reinforcement here is not functionally the same as in laboratory experiments where the correct response is rewarded (reinforced) without opportunity to repeat the response on that occasion.

Student ability to fill in the blank with the word "molecules" in the presence of the other relevant words in the sentence is evidence of knowledge of the subject matter. Such knowledge comes about from prior preparation. If the prior preparation is adequate, the student will be capable of making the correct verbal response. Adequate preparation, in general terms, consists in bringing the student along from the responses (or knowledge) he already possesses to those we expect him to acquire. This is accomplished by the teacher when he decides what the steps are which the student must traverse, how big each step should be, and in what order they should be traversed.

If the judgments about the size of the steps to be made and their order are sound, there will be a high probability that the student will be capable of making a correct response at each and every step. This mastery at each step permits progress to the next. The student is informed promptly of his mastery with knowledge of results.

The conditions just described are synonymous with teacher guidance of student learning. The teacher maintains active control over the learning behavior of his students by presenting them with cues that will, through prior exposure, be sufficient to elicit correct verbal responses. Reinforcement then follows response. The experimental version of lessons described in this study attempted to arrange for these conditions conducive to efficient learning.

The "conventional" lecture, by contrast, provided minimal control of student learning behavior. As has been pointed out (7), without preparation and explicit requirements for students to make specific responses, the instructor does not exercise control over which responses the student will make. Moreover, without the detailed, necessary preparation of steps that students can master sequentially, the probability that responses will be correct at each step is low. There is also customarily no provision in the conventional TV lecture method for reinforcement of specific responses.

The general superiority of the experimental versions of lessons reported in this study can be attributed to what appear to be three key features of programmed instruction. These are: (a) the sequencing or programming of lesson content to enable students to make correct responses at each step; (b) the empirical tryout of the lesson with a sample learning audience to determine whether

correct responses can, in fact, be made (with revision of sequences when they cannot); and (c) provision for active student response followed by feedback of results during lesson presentation.

The relative contribution to learning efficiency of each of these features cannot be assessed by the present study. Not only were the instructional variables not explicitly defined or introduced in the control (conventional) version of the lesson, but the two factors of sequencing and active response were introduced jointly in the experimental version. Thus, the relative contribution of any one factor cannot be assessed. The present study has merely attempted to demonstrate the effectiveness of programmed TV instruction requiring active student responses as opposed to the conventional lecture method of instruction.

The serious difficulties inherent in programming for group instruction should not be glossed over. Even though the programming of lesson content and the encouragement of active student response produce improvements in learning and retention, optimum control over student learning behavior has still not been attained. When individuals within the student audience differ widely in ability and prior preparation, the match between the "program" and the ability of any individual student is not likely to be optimal in a fixed-pace group presentation. The resulting mismatch will seriously affect the probability of correct response. Terminal achievement as measured by a test of student recall of facts or understanding of concepts will, in turn, be impaired.

Efforts toward a reduction of the mismatch would appear to consist of: (a) the development of lessons for, and the presentation of lessons to, audiences homogeneous in ability and background; (b) the empirical tryout of lessons on a strictly representative student audience under strictly representative conditions of instruction; and (c) the exploitation of research results on fixed-pace group instruction.

There is currently little available research evidence that can be applied to fixed-pace, "programmed" group instruction. The experiment reported here represents one of the first studies in this area. Report No. 3 in this series seeks to explore in more systematic fashion the application of programming concepts to fixed-pace instruction over television.

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APPENDIX A

Lecture Materials

1. Scripts on "The Effects of Heat"

a.	experimental lesson	pp. A- 2 - A- 5
b.	control lesson	p. A- 6

2. Scripts on "Nuclear Reactions"

a.	lesson objectives	pp. A- 7 - A- 8
b.	experimental lesson	pp. A- 9 - A-12
c.	control lesson	pp. A-13 - A-16
d.	classroom "active response" worksheets	pp. A-17 - A-21

Script for Experimental Lesson
Heat

I am heating this metal strip with the flame from a bunsen burner. As the strip gets hot, it begins to bend. Why did it bend? Later in our lesson we'll find out why and we'll also find out what happens to any kind of object when we apply heat to it.

To help you to understand the lesson better, every now and then I'm going to pose a question and wait for you to answer it before I give the answer. Every time I pose a question for you to answer, I'll flash a question mark on the screen like this ?/. When you see the question mark, say the answer right out loud. See if you can say the answer out loud before I tell you what it is. O. K.?

This block of wood is a solid object that is made up of tiny particles we call molecules. The water in this beaker is, of course, a liquid which is also made up of tiny particles we call ?/ MOLECULES. Did you say molecules to yourself? Remember to say the answer to yourself before I tell you what it is.

The air in this flask is a gas, and just like the solid block of wood and the liquid water it is also made up of tiny particles or ?/ (what are they called) MOLECULES. Solids like this block of wood, liquids like the water, and gases like the air in this flask are all made up of tiny particles called ?/ (say it out loud) MOLECULES

Objects that are solids, liquids, or gases are all made up of molecules. Molecules are found in ?/ (what kind of objects) GASES. Molecules are also found in ?/ LIQUIDS. They are also found in ?/ SOLIDS. Molecules are found in all three types of objects. What three types of objects are there? ?/ SOLIDS, LIQUIDS, AND GASES.

Molecules are tiny particles and are so small that, of course, we can't see them. But they are there in all kinds of objects. Even in a single drop of water there would be millions and millions of tiny molecules. If we were to draw a picture of one drop of water it would have ?/ (how many molecules) IT WOULD HAVE MILLIONS AND MILLIONS OF MOLECULES.

These millions of molecules are moving all the time. One fact you should remember is that molecules are in constant motion. No matter what the temperature of objects -- whether they are hot or cold or at room temperature -- the molecules in them are in constant ?/ IN CONSTANT MOTION. Regardless of whether they are hot or cold, molecules are in ?/ IN CONSTANT MOTION.

Supposing we heat this metal ball. What will happen to the molecules that are already moving in it? The molecules in this water are already moving. Supposing we start heating this water. What will happen to the moving molecules? They will begin to move faster than before. Whenever we heat liquids, solids, or gases, the molecules in all three types of objects will move faster than before. So, whenever we heat objects, we can say that the molecules, compared to how fast they moved before, will now move ?/ (how) FASTER.

The opposite is also true. Whenever we remove heat from objects, that is, whenever we cool them off, the molecules will move more slowly than before. If I remove the flame from this beaker of water and let it become cooler, the speed

of the moving molecules will decrease. The molecules will now move more ?/ (more what) SLOWLY. The speed with which the molecules in objects move depend on how much heat there is in the object. So, in summarizing, we can say that the amount of heat in an object determines the ?/ (what) THE SPEED WITH WHICH THE MOLECULES MOVE.

Supposing the molecules in this metal ball do move faster. What will happen to the metal ball as a result? When these molecules which are moving in all directions begin to move faster they move farther apart from one another. When molecules move faster they move farther ?/ FARTHER APART FROM ONE ANOTHER. The molecules move farther apart from one another because they are moving ?/ (how) FASTER. When the molecules in this metal ball move farther apart from one another the metal ball gets bigger or expands. Expansion means to get bigger.

Let's heat the metal ball now. Can we see it expand? Let's cool it off. Can we see it get smaller? No we can't see it change size. Let's use this ring to show that the ball <u>does</u> expand when we heat it even though we can't see it expand.

Before we heat the metal ball we can put the ball through the ring and we can take it out. Now let's heat the ball again. Now we can't get it out. This means that the metal ball has gotten bigger or expanded. Heating the metal ball made the molecules move farther apart from one another and as the molecules moved farther apart from one another the metal ball got bigger or ?/ (did what) EXPANDED. The metal ball expanded, when compared to before, the molecules now begin to move <u>faster</u> and ?/ (what) FARTHER APART FROM ONE ANOTHER.

Most solid objects will expand when the molecules do what ?/ WHEN THE MOLECULES MOVE FARTHER APART FROM ONE ANOTHER. The molecules moved farther apart when they began to move faster. Supposing the molecules move more slowly now. What will happen to this metal ball? Let's cool off the metal ball now by dipping it in cold water.

Now I can pull the ball out through the metal ring. The ball became smaller or contracted. Contraction means to get smaller. Taking heat away or in other words cooling off the solid metal ball slowed down the molecules in it and they didn't move as far apart as before and then the ball became smaller or ?/ (did what) CONTRACTED.

Contraction occurs when heat is taken away and the molecules, compared to before, move more slowly and not so far ?/ APART. Most solid objects will contract when heat is taken away and the molecules don't do what ?/ DON'T MOVE AS FAR APART.

Let's review a few points now. First: Heating a solid affects the speed of the molecules. Adding heat makes the molecules in the solid object do what ?/ (say it out <u>loud</u>) MOVE FASTER. Second: When molecules move faster, the molecules move farther ?/ APART. Third: When the molecules move farther apart, the solid object ?/ EXPANDS. Fourth: Cooling a solid object also affects the speed of the molecules. It makes them move ?/ MOVE MORE SLOWLY. Fifth: When molecules move more slowly and they don't move as far apart, the solid object does what ?/ CONTRACTS.

Here's another solid object. It is called a bi-metal bar. A bi-metal bar is a bar that is made up of <u>two</u> different metals. This bar is made of brass on one side and steel on the other. Therefore, we can call it a ?/ (what kind of bar) BI-METAL BAR.

When we heat this bi-metal bar we'll find that it will bend. This is so because, when the brass and steel reach the same temperature, the brass will expand more than the steel will. Since the two metals are stuck together and one expands more than the other, the bar will have to bend. Let's watch. Now it doesn't make any difference which side we heat. The brass expands more than the steel does and the bar bends.

We did this demonstration to show you that although solid objects expand when heated, some of them expand more than others. At a given temperature the molecules in brass will move slightly farther apart than the molecules in steel. As a result the brass will expand more. In our demonstration, brass expanded more than steel because the heat made the molecules in the brass part, compared to the steel part, move ?/ (how) FASTER AND FARTHER APART.

The molecules in the steel part didn't move as far apart as the molecules in the brass part of the bar and therefore, compared to the brass, (fill in the blanks) THE STEEL EXPANDED LESS. When you reach a given temperature each metal expands a different amount. Brass, steel, silver, lead, tin, all expand different amounts. Brass has its own amount of expansion. Steel has its own amount of expansion. Each type of solid has its own amount of ?/ (what) EXPANSION.

What about liquids? Do they expand too? Let's heat this colored water. The water down here expands and rises in this column. When heated, the molecules in liquids move faster too and farther apart and as a result liquids also ?/ (do what) LIQUIDS EXPAND.

But liquids expand very much more than solids. We couldn't see the metal ball expand. But we could see the water rise up the column. The rising water meant it had expanded. Which expands more, liquids or solids? ?/ LIQUIDS EXPAND MORE THAN SOLIDS. Heat speeds up the molecules in liquids more than in solids; the molecules in liquids also move farther apart than in solids. Therefore compared to solids what do liquids do? ?/ THEY EXPAND MORE.

The speed of molecules in gases are increased even more than in liquids and they move even farther apart. As a result, gases expand more than liquids. Let's show how much gases expand.

Here's some air in this flask. Let's heat the air. The balloon inflates because when the air in the flask is heated it expands very much and fills the balloon. Because the speed of the molecules in gases is increased more easily than the molecules in liquids, compared to liquids, gases expand ?/ (how) MORE. Gases expand very much more than liquids and liquids expand very much more than solids.

Which expands the most ?/ (liquids, solids, or gases) -- say it out loud -- GASES. Which expands the least ?/ (say it out loud) SOLIDS. Which is in between ?/ (say it out loud) LIQUIDS.

The difference in how much or the amount that solids, liquids, and gases expand depends on how fast their molecules move and on how far apart their molecules move. The differences in the amount of expansion in solids, liquids, and gases depend on what ?/ (say this answer to yourself) HOW FAST AND HOW FAR APART THEIR MOLECULES MOVE.

In addition to expanding or contracting, something else can happen to solids, liquids, or gases. They also undergo a change of state. Changes of state means that

solids can turn into liquids or liquids can turn into gases. Let's see some examples.

Here's some ice in a test tube. Now we know ice is a solid. By adding heat to the solid ice we can turn it into a liquid. Watch. The ice which is a solid was turned into water when we added heat to it. We can say that we can turn a solid into a liquid by adding what to it ?/ BY ADDING HEAT TO IT. By adding more heat to it we can turn the liquid into a gas. Watch. When we add more heat to the water we turned it into a gas -- in this case, steam. So we can say that by adding heat to a liquid we can turn it into a ?/ (what) GAS.

Liquids will undergo a change of state -- they will turn into a gas when we do what to it ?/ WHEN WE ADD HEAT TO IT. Adding heat will turn a solid into what ?/ A LIQUID. Adding heat to a liquid will turn it into what ?/ A GAS.

Now instead of adding heat suppose we take heat away -- in other words -- what changes of state occur when we cool things off? Suppose we use this condenser to cool steam off. We're passing the steam which is a gas through the condenser. The condenser removes heat from it. Removing heat from the gas turns the gas into a liquid. The steam is turned into a liquid when we remove what from it ?/ HEAT.

Now let's take this liquid and cool it off by putting it into a freezing solution. The liquid turns into a solid-ice when we cool it off or remove what from it ?/ HEAT. Removing heat from a liquid will cause it to change to a ?/ SOLID. These are the changes of state that occur when we remove heat: gases turn into ?/ LIQUIDS, liquids turn into ?/ SOLIDS.

Adding or removing heat causes expansion or contraction and also changes of state in solids, liquids, and gases.

Script for Control Lesson
Heat

Same as script for experimental lesson on heat - in experiment No. 1 in report No. 1.

Lesson Objectives

Nuclear Reactions

A. <u>Comparison of three types of reactions or changes: physical, chemical, and nuclear:</u>

1. In physical change or reaction - molecules remain intact.

   e.g. in changes of state which are physical reactions (such as water turning into ice) the molecule of water - H_2O remains the same.

2. In chemical change or reactions the molecule breaks down into its smaller parts. The molecule breaks up into atoms which can recombine in different ways; but the atoms themselves remain intact; <u>whole</u> atoms combine in different ways.

   see example below in B-4.

3. In a nuclear change or reaction the atoms themselves are broken down; the nucleus of an atom that is broken down changes; the nucleus being changed forms a new and different kind of atom.

   see example below in B-4.

B. <u>Further comparison of chemical and nuclear reactions or changes</u>:

1. Energy is released in the form of light, heat, or sound in both chemical and nuclear reactions.

2. But chemical and nuclear reactions differ; the nature of interactions differ, as just seen.

3. A key aspect of the difference between chemical and nuclear reaction is the destruction of matter in the latter as revealed by the loss of weight.

   a. In a chemical reaction although energy may be liberated, matter is <u>not</u> destroyed; the weight of the final product equals the weight of the original components.

   b. In nuclear reactions matter is destroyed (converted to energy); the weight of the final product is less than that of the original components; the lost (weight) (matter) has been converted to energy.

4. Example comparing the two reactions.

   a. When hydrogen gas burns energy (heat) is released (chemical reaction).

      (1) burning means two hydrogen atoms combine with one oxygen atom to form an H_2O molecule.

      (2) heat is released, water is left.

      (3) this is a chemical change.

      (4) weight of starting and resulting product are equal.

   b. When hydrogen gas undergoes fusion, energy (heat, light) is released.

      (1) two H atoms combine, form a heavier atom.

      (2) heat is released, the heavier atom is left.

(3) the total weight of new atom is less than combined of old two - i.e. matter has been lost.

(4) this is a nuclear (sub-atomic) change.

c. The energy given off when two H atoms fuse, that is combine, is about a MILLION times more than that energy given off when 2 H atoms combine with oxygen.

d. The fusion reaction is VERY POWERFUL.

Script for Experimental Lesson
Nuclear Reactions

Today we're going to compare three types of changes: physical change, chemical change, and nuclear change. Because this topic is a very important one, we're going to have a slightly different kind of presentation, and I'd like you to pay particularly close attention.

At various times in the lesson, I'll review a few key points by flashing them on the screen. The sentences will have blank spaces. The sentences are the same as those on the forms you've been given. When I show them on the screen, see if you can fill in the blanks with the correct answer before I tell you what it is. Also, sometimes while I'm talking I will pause a moment before I say a key word. I'll flash a question mark on the screen when I'd like you to think of the key word. See if you can think of it before I say it. Doing this will help you to learn the lesson better.

Let's talk about how matter undergoes physical changes or physical reactions.

Do you remember from previous lessons when Mr. Shaffer talked about changes of state? Water turning into ice is an example of a change of state. Boiling water turning into steam is another example of a ?/ (can you think of the correct answer) change of state.

Changes of state are called physical changes or physical reactions. The change of water into ice or water into steam are examples of physical reactions or ?/ physical changes.

Here's an illustration of the physical changes that occur with water. We know that all three, ice, water, and steam are different forms of matter because they all weigh something. Matter is anything that has ?/ (what) that's right, weight. Matter can also be divided into tiny particles called molecules. All liquids, all gases, all solids, in other words all forms of matter, can be divided into tiny particles which we call ?/ molecules.

What happens to the molecules in matter when matter undergoes a physical change or reaction? Let's go back to our three examples of matter: ice, water, and steam. All three have weight and are therefore different examples of ?/ matter. Being matter they can be divided into tiny particles which we have called ?/ molecules.

Now, all three, ice, water, and steam are made up of H_2O molecules. Two atoms of hydrogen and one atom of oxygen are joined together to form one H_2O molecule.

When water freezes and turns into ice, nothing happens to the H_2O molecule. It remains the same or intact. Or when ice melts and turns back into water, nothing happens to the H_2O molecule; it's the same as before; the molecule remains the same or ?/ intact. This is also true when water is boiled and turns into steam or steam is turned back into water. Nothing happens to the H_2O molecule; it remains the same or ?/ intact.

Let's review what we said about physical changes or reactions. Watch the television screen and then on the forms that you've been given, see if you can quickly fill in the blanks that will complete the missing words.

Point number 1: Changes of state are examples of P H _ _ _ _ _ _ C H _ _ _ _
(fill it in on your forms).

Point number 2: When matter undergoes physical change molecules remain I N _ _ _ _
(fill it in on your forms).

Point number 3: When ice melts or water boils, nothing happens to the H_2O _ _ _ _ _ _ _ _.

Do molecules remain the same or intact in chemical reactions or changes? The answer is no. In chemical reactions molecules do not remain the same or ?/ intact. The molecules break down into atoms in chemical reactions. In chemical reactions, the molecule breaks down into smaller parts of which molecules are made, and, we know from previous lessons, that the smaller parts of a molecule are called ?/ atoms.

What happens to the atoms in a chemical reaction or change? The molecules break down into atoms and the atoms recombine in different ways, forming new or different molecules. New molecules are formed in chemical reactions resulting from a rearrangement or recombination of ?/ atoms.

Suppose we take some hydrogen gas and burn it. A chemical change would take place when we burned hydrogen gas. The hydrogen atoms in hydrogen gas would rearrange or recombine themselves in different ways. The molecule of hydrogen gas would break down into hydrogen ?/ atoms and the atoms would be rearranged or ?/ recombined. The atoms would be recombined in new or different arrangements.

What arrangements would result? Two hydrogen atoms from hydrogen gas and one oxygen atom from the air would combine to form water. Thus when hydrogen gas is burned, hydrogen atoms combine with oxygen atoms in the air and water is formed. Also heat is released. A chemical reaction has taken place; for the molecules of hydrogen gas broke down into hydrogen atoms and the atoms recombined in new ways. They combined with oxygen atoms from the air to form water molecules. A water molecule is formed when two atoms of ?/ hydrogen combined with one atom of ?/ oxygen.

When hydrogen gas, which is one form of matter, burned heat was released and water, which is another form of matter, was produced.

Let's review what we said so far about chemical reactions.

Point number 4: In chemical reactions, molecules break down into _ _ _ _ S.

Point number 5: Atoms recombine in chemical reactions to form new _ _ _ _ _ _ _ _ S.

Point number 6: The reaction that occurs when atoms recombine in new ways is called a _ _ _ _ _ _ _ _ change.

What are some of the other characteristics of chemical reactions or changes? For one thing, energy is released in chemical reactions. When we burn hydrogen gas we produced a chemical change. In the burning of hydrogen gas energy in the form of heat is released. Heat is a form of ?/ energy. The flame of the burning hydrogen gas also gave off energy in the form of light. Heat and light are forms of ?/ energy. Releases of energy in one form or another occur in all chemical changes or ?/ reactions.

Here's another characteristic of chemical reactions. In chemical reactions, when atoms recombine to form new molecules, the weight of the atoms in the new molecule exactly equals the weight of the original atoms in the old molecule. There is no loss of weight of the atoms in chemical changes. The atoms of hydrogen gas before it was burned weighed 2. The oxygen atom in the air weighed 16. The combined weight was 18. When the gas burned it gave off heat and also combined with oxygen in the air. The water molecule that resulted from the recombination of the hydrogen atoms and the oxygen

atom weighed 18. The atoms in the final product, water, weighed the same as the atoms of oxygen in the air and the atoms of hydrogen in the hydrogen gas that we started with. In chemical reactions when atoms combine in new ways, the weight of the atoms in the final product exactly equals the weight of the atoms in the beginning product. There is no loss of ?/ weight.

Let's review the last few points we made.

Point number 7: In chemical reactions there is always some release of E N _ _ _ _.

Point number 8: Heat or light are forms of _ _ _ _ _ _.

Point number 9: When atoms recombine chemically in new ways, there is no loss of W _ _ _ _ _.

The third type of change or reaction that matter can undergo is called nuclear. In nuclear reactions, even the atom breaks down into its parts. The atom breaks down into smaller parts in a nuclear change or ?/ reaction. The smaller part of the atom we're concerned with is the nucleus. Nuclei is the plural of nucleus. Now, the nucleus of one atom can interact with the nucleus of another atom; the two nuclei interact and can rearrange themselves and form a new type of atom. By nuclear change, we mean the interactions or recombination of ?/ nuclei. This recombination of nuclei forms a new type of ?/ atom.

Let's take an example. Fusion is one type of nuclear reaction. When hydrogen gas undergoes fusion, the nuclei of the two atoms of hydrogen interact. The nuclei of atoms interact in fusion reactions. Thus, one example of a nuclear reaction is ?/ fusion. In fusion, the nuclei of the atoms of hydrogen gas interact and combine to form a new ?/ atom. The new atom is formed by the interaction of ?/ nuclei. The new atom is a helium atom. When the nuclei of two atoms of hydrogen interact in a fusion reaction, a new atom is formed and it's a helium atom. The nuclei interact and combine to form a new atom, a ?/ (what kind of atom) helium atom.

Reviewing some of the points we covered on nuclear reaction or change we can say the following:

Point number 10: In nuclear reactions there is an interaction between _ _ _ _ E I.

Point number 11: The interaction of nuclei in a nuclear reaction results in a new _ _ _ _.

Point number 12: The combination of two hydrogen atoms is called F _ _ _ _ _.

The new atom that is formed when two hydrogen atoms undergo fusion weighs less than the two original hydrogen atoms. The two hydrogen atoms originally had a weight of two. When these two atoms underwent fusion -- the two nuclei of the hydrogen atoms interacted and formed a new ?/ atom. This new atom weighs less than the original two. It now weighs about 1.997.

Thus, in nuclear reactions when nuclei interact and a new atom is formed, there is a loss of ?/ weight. See, the two hydrogen atoms weigh more than the new helium atom which was formed. Some weight was ?/ lost. We remember from the last lesson that the lost weight shows that matter has been destroyed. If matter has a certain weight to begin with and after a nuclear reaction it weighs less, this means that some matter has been

destroyed. Since matter has weight, if matter after nuclear reaction weighs less, we know that some matter has been ?/ destroyed.

What happened to the matter that was destroyed? It has been converted into energy -- energy in the form of light or heat. In a hydrogen bomb, for example, fusion destroys some matter and that matter is converted into ?/ energy. Energy in an explosion of a hydrogen bomb is released in the form of light or heat ?/ energy. The amount of energy released is tremendous -- indicated by the formula we talked about last time -- $E = MC^2$. More energy is released from a tiny bit of matter in a nuclear reaction than is released in a chemical ?/ reaction. Remember the weight of the two hydrogen atoms only went down from 2 to 1.997. Thus only a tiny amount of matter was destroyed and yet it was converted into a tremendous amount of ?/ energy.

Let's review again.

Point number 13: In fusion reactions the new atom formed weighs _ _ _ _ than the original.

Point number 14: The loss of weight indicates that matter has been D _ _ _ _ _ _ _ _.

Point number 15: Matter that has been destroyed is converted into E _ _ _ _ _.

Point number 16: Energy released in nuclear reactions is tremendously greater than in C H _ _ _ _ _ _ R _ _ _ _ _ _ _ _.

Now let's review the same points from the entire lesson on physical, chemical, and nuclear reactions or changes.

Point number 17: When matter undergoes physical change, molecules remain the same or I N _ _ _ T.

Point number 18: When matter undergoes chemical change, atoms recombine to form new M O _ _ _ _ _ _ S.

Point number 19: In chemical change there is no loss of weight, but there is also a release of _ _ _ _ _ _.

Point number 20: In nuclear change there is a loss of weight indicating that matter has been D E S _ _ _ _ _ _.

Point number 21: When matter undergoes nuclear change, the destroyed matter is converted into E N _ _ _ Y.

Point number 22: The release of energy is the greatest in N _ _ _ _ _ R R E _ _ _ _ _ _ S, because _ _ _ _ _ _ is transformed into _ _ _ _ _ _.

In the next few lessons Mr. Shaffer will tell you more about nuclear reactions.

Script for Control Lesson

Nuclear Reactions

What else might I do with these paraffins of a candle? Instead of just changing them from solids to liquids isn't it possible to take a match and actually have the candle burn, like that? Here are some more changes in a candle. Now you see changes. A variety of changes and I wondered if we might not make some groupings now of these kinds of changes that we've seen.

Let's start with something that we ended up with. The change that has taken place in this spoon. I took some solid paraffin, held it over a flame like that and the solid paraffin was changed to a liquid. You've identified this and studied it as a change of state. What you're seeing here is something that is called a physical change. Why is it a physical change? It's because I didn't break apart any molecules of the paraffin. No molecule has been affected, there's just a change of state here. That's all. No molecule has been affected. A physical change.

We'll, let's see if we can't find some physical changes with this coin. Do you recall when I took the coin and rubbed it with steel wool, I made it very nice and shiny. I removed some of the outer surfaces of tarnish off the coin but I didn't change or break or make any new molecules. No molecule of that coin was broken apart at all. This was another example of a physical change. But, remember this spot over here. When I lit a match and held it on the coin, that was different wasn't it? Let's just be concerned with this physical change. No molecule was affected in this silver coin. And the paper. What about the tearing of the paper? I made little pieces from a larger piece of paper. Little ones out of a big one. But I didn't change in any way any molecule of paper did I? No. This was a physical change.

Now, let's come back and review again. With the burning of the candle first. The burning of the candle. This is just a little bit different than the melting of a candle in a spoon. There wasn't a change of state really. Maybe there was in the beginning but the actual burning of the candle is something all together different. No. This has to be another kind of change and I think to really find out what happens when changes are taking place here then we're going to have to represent this candle somehow and talk about it. First, what's the candle made from? The candle is made from something called paraffin. Molecules of paraffin. I'm just going to put the *word paraffins up here to represent the candle and in those molecules that make up* paraffins there are lots of atoms of hydrogen and lots of atoms of carbon. Now when burning takes place, when the candle burns, there is a change taking place. What is happening is that the molecules that make up the paraffins in the candle are being broken apart. The atoms are being disassociated one from another and some new atoms are being made. For example, we'll take some carbon from one of the molecules in the paraffin and the carbon atoms broke out from molecules of paraffin combine with some of the oxygen in the air and look, a whole new molecule is made from atoms of molecules of paraffin. An atom of carbon has combined now with two atoms of oxygen in the air and we have something that you know as carbon dioxide.

But that's not the end of the story. Some of these hydrogen atoms from the molecules are broken up, the molecules of paraffins and they can come down and combine with oxygen in the air, this is what burning is, oxidation. Whenever two hydrogen atoms are broken off from a molecule of paraffin and they combine with one atom of oxygen in the air, H_2O, water is there. This is an example now of a chemical change. Chemical change not a physical change. We have broken apart molecules, reused these atoms, they've rearranged themselves to make new molecules. This is a chemical change.

.Now, let's come back and think about some of these other things we've done. How about that coin that had atoms of silver in it? We saw how we could make some physical changes there. But recall now, I took a match, and I lit a match and I held the match, as it was burning, on the coin and the black mark was there. Some of the molecules that had been in the match had broken apart and combined with the silver in the coin. New molecules were made from ones that had been broken apart. A chemical change. Nothing was especially destroyed. Here everything was just changed around and used in another way and we had a little bit of heat maybe or light as we had from the candle. Again chemical changes. Same thing with the paper. We took paper and this time instead of tearing it to make little pieces from a big piece we did something different. We burned it much like we did the candle and this time though we broke up the molecules of paper, broke them up, rearranged them and made some new molecules, new substances. This was, then, a chemical change. Not physical, chemical. Molecules of something were broken up, atoms broken apart one from the other and rearranged in some new substances making a new molecule.

Now, there's something we must remember here in these chemical changes. Whenever there are changes, chemical changes there are also changes in energy. As you have seen, heat and light in some cases were given out when we had seen these chemical changes. Now I'd like to spend a little bit of time talking about these energy changes that you've seen. You've seen energy changes taking place in the burning of this candle, in the burning of paper and even with a match. Heat and light in most cases were given off. I think I might refresh your memory a little bit more. How about some common substances you've seen many times and in many cases used in your home. You make chemical changes take place every time you use fuel. One kind of fuel is coal. You can burn coal can't you? When you cause the chemical change of coal burning, heat and light aregiven off. Energy changes must be thought of whenever we think of chemical changes. One thing we might mention now, in chemical changes it might appear that something is destroyed or used up like a candle or coal but it isn't. You've just rearranged, changed molecules of the substance around and made new ones. Nothing has been destroyed. But actually if you wanted to talk about weight, you could weigh things, no weight has been lost along the line.

Now, let's come back and take a look again, kind of reviewing, comparing physical changes and chemical changes. First, physical changes. I'll represent physical changes by this block of ice. A block of ice made from molecules. Molecules made of hydrogen and oxygen, water. I could melt this and make a change of state or maybe I'd like to take a hammer and break the ice. I could do that and I would be speaking about a physical change and can you tell me why? Look. Breaking up ice. Tell me now, have I broken apart any molecules of ice? Have I broken apart any hydrogen and oxygen atoms that make a molecule of water? No, I have not. I have not changed any of these molecules of the ice even though I've changed it so it can be identified now as a physical change. A physical change. Now let's stop and think some more.

One of the changes, the second kind, a chemical change. Let me represent the chemical change for you in an old familiar friend you've worked and seen before. This represents the electrolysis of water. Breaking up of water. Another kind of chemical change. Look, a container filled with water. H_2O molecules. In the water some acid so current electricity from a battery can flow through wires. These wires we could put in test tubes but the important thing is we want to take molecules of water, made of hydrogen and oxygen, and break them apart. Divorce them one from another and you do that with electrolysis. We can take this and remove the H, the hydrogen, collect it in one tube and from that molecule of water that we're breaking up collect oxygen as a matter of fact aren't we breaking up and collecting twice as much hydrogen as oxygen when we break apart these molecules of water? I want you to

keep in mind though, when you break up molecules within a substance and have them recombine, reform and possibly make new molecules of some thing, this is a chemical change. We haven't destroyed anything. There isn't any difference in weight of anything. We've just taken things and reused them in different ways.

But this isn't the end of the story. We'll have to go a little bit further and take a look at an atom itself. Let me represent an atom of carbon for you. We can represent it like this. How good are you about remembering parts of atoms? This one happens to be copper carbon. The center of an atom is called nucleus made from protons and I've represented them with a circle with a plus and neutrons I've represented them with a circle with no charge in them. The center of an atom. Then, revolving round and round and quite a distance from the nucleus are these tiny bits of matter that we've spoken about and identified as electrons. Now I want you to remember that in chemical changes, everything that takes place is between these electrons. It has nothing to do with the nucleus. The energy that is released and as you've seen, in terms of light and heat, has to do with these electrons not the nucleus. This takes place now in chemical changes. But now we have to be concerned with another part of an atom and really that third kind of change that I mentioned. Can you remember the name of it? I think you can. Didn't I say something about nuclear changes? Nuclear changes. Now we want to talk about this nucleus. When you talk about more than one nucleus then you can use the word nuclei. We want to see what kind of energy changes can take place in the nucleus of an atom.

Now to do this, we are going to need some help from you. That means I have to have the help of your imagination. We're going to have to use our imagination because I can't show you one or two or a few atoms. But I can talk about them. Let me see if you can think with me. Think about a nuclear change now. Something that happens in the nuclei of atoms. To do that I'm going to use a balance for you. I'm going to put things on this balance. Let's imagine that we have one hydrogen atom. We're going to weigh the hydrogen atom. The weight of one hydrogen atom we'll say is just 1. Put a one there. Now let's say that we want to make a nuclear change, in fact, make nuclear changes but I have to consider another nucleus of a hydrogen atom again weighing 1. Now if I could make a nuclear change and make these two atoms of hydrogen in the nucleus go together and make one, this would be a nuclear change.

Let me ask you some questions. If I make these two nuclei of hydrogen atoms with a weight of one go together wouldn't you suspect that the weight of the two of them being put together would have a weight of two? That's what you would suspect. Then both sides of this balance would be equal. Now, a strange thing happens and this is something I want you to think about. Let me remove this tool. Whenever we cause nuclear changes, by nuclear change I mean when we make nuclei of atoms combine or go together, change to form one new atom, something happens to weight. In this case, whenever we put two atoms of hydrogen together the new atom that's going to be made will not have a weight of two. Here's what would happen. Let me represent it this way for you. I'll call this new atom X. We've made a new atom of something by combining the nuclei of two hydrogen atoms. Here is just one atom of something. Something new and it doesn't weigh two. It has lost some weight. As a matter of fact, according to this, our balance, it only weighs 1.997. Now the problem is, what's happened to that weight? We've lost something. Well, that weight that's been lost when we combined two nuclei of hydrogen atoms to make atom X has been turned into energy. We've destroyed some weight and changed it into energy. Some very, very small amount of weight, we'll say, has been destroyed. We'll represent it by that. See what happens when I put that little bit of weight back. It balances again. But we loose it when we put together atoms that is the nuclei of atoms. Nuclear changes. In all nuclear changes weight is lost, destroyed and changed into energy. The new atom weighs less.

Now, here comes another problem. We have to perhaps give a name to this process of nuclear change where you take nuclei of atoms, in this case two hydrogen atoms, combine them, put them together, and make one new atom of something. There is the new atom. The name that we can give, apply to this process of nuclear change, this kind of combining things into one is called fusion. Fusion, this is the name of the process of this kind of nuclear reaction. Fusion. Keep that in mind because there are other names of nuclear reactions that we'll be familiar with later. Now, the interesting thing to think of here is some comparisons. Remember I said energy is released when we have chemical changes and nuclear changes. How about a comparison of how much energy is released in a chemical change as to what is released in nuclear changes.

Let's come back to an old friend. Something very common. You know this fellow. Coal. A pound of coal and I think you are familiar with how much light and heat you can get from a pound of coal. That is by chemical changes, burning. Let me tell you this, if I could cause nuclear changes to take place here, this process of fusion, then how much energy do you think I should get from this coal. In terms of light and heat. Well, I'll give you a figure and I'm sure it will be too big for you to imagine. With nuclear change, I could get one million more times energy, light and heat, from a pound of coal in nuclear changes than I could with chemical changes. Maybe I could show you this in another way. If I had one pound, well to get the amount of heat from one pound of coal in a chemical change eight railroad cars of about 500 tons of coal would have to be burned by chemical change to give me the amount of energy that I could burn from a one pound block of coal by having nuclear changes. Nuclear changes actually destroy a small bit of matter. Losing weight of the coal and changing it to energy. Isn't that an interesting comparison of the amount of energy released from chemical changes and nuclear changes?

Now, let's go back and tie together very hurridly what we've been speaking about today and what we've been comparing. For instance, chemical changes. Remember in chemical changes they are changes that take place where no molecules, any substance, is broken apart. I'm sorry, I think I've confused you. Physical changes. Didn't we cover these first? Yes, physical changes. We do not affect or change molecules of the substance. We may change state but we do not break up molecules or substances in physical changes.

Second, chemical changes. This is a bit different. In chemical changes, we actually take molecules of substances, break them apart and then take the broken apart pieces, atoms, recombine or rearrange them and make new molecules. This process of rearrangement, breaking apart, causes the release of energy. Usually heat and light. That was the second change. A chemical change.

The third thing we spoke of was nuclear reactions. Here we are concerned with the nuclei of atoms, a process of fusion where we take two nuclei of atoms, combine them, put them together to make one new atom. And in the process of fusion, putting things together, we lose a tiny bit of weight. This tiny bit of weight that has been lost in nuclear changes and fusion we have talked about today, then this loss of weight is turned into energy. Those are the three processes and comparisons we want you to remember. Physical changes, chemical changes, and nuclear changes. I hope you know them and at some later day I'm sure Mr. Shaffer will be back and talk more to you about nuclear changes or nuclear reactions. I think you'll enjoy them very much and keep in mind that fusion, the one we've spoken about today is only one kind of nuclear change.

WQED

Junior High School Science

Lesson on: Nuclear Reactions

Name _____ Grade _____ 7th or 8th

School _____

Instructions: Fill in the information at the top of the page.

1. Today's science lesson on nuclear changes will be given by Mr. Chemas.

2. Throughout the lesson Mr. Chemas will pause to let you think of words we'd like you to learn. See if you can think of the correct words before Mr. Chemas tells you what they are.

3. Sometimes Mr. Chemas will also stop to review some key points. He will show you some sentences on the screen which have some blanks in them. The same sentences are in the booklet I just gave you and there are blanks in the booklets too. Each blank means that a word is missing. If one word is missing, there will be one blank. If two words are missing, there will be two blanks.

4. Mr. Chemas will review each key point in the lesson and give it a number. We would like you to write in the correct missing word in your booklets alongside the point number he mentions. There is a blank space for each letter in the word.

5. For example:

   If Mr. Chemas were to show this key sentence on the screen and say:

   Point number 1: Steam results when we b_ _ _ _ _ _ _ _ _ _

   You would write in the correct words in the spaces alongside point number one in your booklets. Write in the correct words. (Pause) If you wrote "boil water" you're correct.

6. After Mr. Chemas tells you the correct answer, look back at the television screen and wait for the next key point. If your answer is not correct, don't bother to correct it. You might miss the next point.

7. Remember, sometimes Mr. Chemas will pause to let you think the correct word! When he wants you to write the correct word in your booklets he will say -- Point number one - or point number two and so on.

8. Don't open your booklets until Mr. Chemas tells you to write in the correct words.

9. Don't take any other notes during the lesson. We will give you some notes later on.

Point Number

1. Changes of state are examples of p h _ _ _ _ _ _ c h _ _ _ _ .

2. When matter undergoes physical change molecules remain i n _ _ _ _ .

3. When ice melts or water boils nothing happens to the H_2O _ _ _ _ _ _ _ _ .

NOW WATCH THE TV SCREEN

4. In chemical reactions molecules break down into _ _ _ _ s .

5. Atoms recombine in chemical reactions to form new _ _ _ _ _ _ _ _ s .

6. The reaction that occurs when atoms recombine in new ways is called a _ _ _ _ _ _ _ _ change.

NOW WATCH THE TV SCREEN

Point Number

7. In chemical reactions there is always some release of e n _ _ _ _ .

8. Heat or light are forms of _ _ _ _ _ _ .

9. When atoms recombine chemically in new ways there is no loss of w _ _ _ _ _ .

NOW WATCH THE TV SCREEN

10. In nuclear reactions atoms break down and there is an interaction between _ _ _ _ e l .

11. The interaction of nuclei in a nuclear reaction results in a new _ _ _ _ .

12. The combination of two hydrogen atoms is called f _ _ _ _ _ .

NOW WATCH THE TV SCREEN

Point Number

13. In fusion reactions
the new atom formed
weighs _ _ _ _ than the original.

14. The loss of weight indicates
that matter has been d _ _ _ _ _ _ _ _ .

15. Matter that has been destroyed
is converted into e _ _ _ _ _ .

16. Energy released in nuclear reactions
is tremendously greater
than in c h _ _ _ _ _ _ r _ _ _ _ _ _ _ _ .

NOW WATCH THE TV SCREEN

17. When matter undergoes physical change,
molecules remain the same or i n _ _ _ t .

18. When matter undergoes chemical change,
atoms recombine to form new m o _ _ _ _ _ _ _ s .

19. In chemical change
there is no loss of weight, but
there is also a release of _ _ _ _ _ _

Point
Number

20. In nuclear change
there is a loss of weight
indicating that matter
has been d e s _ _ _ _ _ _ .

21. When matter undergoes nuclear change,
the destroyed matter is converted
into e n _ _ _ y .

22. The release of energy
is the greatest in
n _ _ _ _ _ r r e _ _ _ _ _ _ _ s ,
because _ _ _ _ _ _ is transformed
into _ _ _ _ _ _ .

APPENDIX B

Achievement Tests

1. Tests on "The Effects of Heat"

   a. pre-test pp. B- 2 - B- 5
   b. immediate post-test pp. B- 6 - B- 7
   c. delayed post-test pp. B- 8 - B- 9

2. Tests on "Nuclear Reactions"

   a. pre-tests pp. B-10 - B-17
   b. post-tests pp. B-18 - B-25

Heat

Pre-Test

ACHIEVEMENT TEST

WQED

Junior High School Science

Name _____ Grade _____ 7th or 8th

School _____

PART I: 6 minutes

Instructions: Answer the following questions in your own words.

1. What changes of state occur when you add heat to objects?

2. What changes of state occur when you remove heat from objects?

3. If you want to bring about the expansion of a gas like air what would you do to it?

4. Explain why your action would bring the expansion of air.

PART II - FILL-INS: 5 minutes

Instructions: In the blanks below, fill in the word or words which makes the sentence correct and complete.

1. The state of matter which expands the most when heated is a _____.
2. An increase in the _____ of molecules will cause an object to expand.
3. We can cause an object to contract by removing _____ from it.
4. The part of a thermostat which is heated and cooled is made of a _____.
5. A liquid can be turned into a solid by _____ heat.
6. The state of matter which contracts the least when cooled is a _____.
7. A decrease in molecular motion will cause an object to _____.
8. Water is not used in thermometers because as it begins to freeze it _____.
9. If we remove heat from a gas, the gas will turn into a _____.
10. By applying _____ to an object we can speed up the _____ of its molecules.

PART III - MULTIPLE CHOICE ITEMS: 5 minutes

Instructions: Each of the incomplete statements or questions below is followed by several possible answers. In the space provided, put a check mark ✓ next to the answer you think is best.

1. Changes in the movement of molecules bring about

____ a. expansion of gases.
____ b. expansion of solids.
____ c. contraction of liquids.
____ d. contraction of solids.
____ e. all of the above.

2. The process of ice melting and turning into water is called

____ a. expansion.
____ b. contraction.
____ c. change of state.
____ d. all of the above.
____ e. none of the above.

3. At room temperature, molecules in objects are

____ a. contracting.
____ b. expanding.
____ c. moving.
____ d. standing still.
____ e. changing shape.

4. Expansion and contraction occur in

____ a. gases only.
____ b. liquids only.
____ c. solids only.
____ d. solids and liquids.
____ e. gases, liquids, and solids.

5. At certain temperatures, which of the following shows an <u>exception</u> to the general rule that objects keep contracting when they cool off?

____ a. air
____ b. iron
____ c. liquid alcohol
____ d. mercury
____ e. water

6. When you add heat which of the following will expand the <u>most</u>?

____ a. air
____ b. copper
____ c. steel
____ d. water
____ e. all about equally

7. A practical use of the expansion qualities of a bi-metal bar is found in a(n)

_____ a. air thermometer.
_____ b. bell.
_____ c. bunsen burner.
_____ d. thermostat.
_____ e. all of the above.

8. Water is <u>not</u> used in thermometers because as heat is removed from it and the temperature nears zero degrees centigrade it

_____ a. changes state.
_____ b. contracts.
_____ c. expands.
_____ d. freezes.
_____ e. none of the above.

9. When heat is <u>applied,</u> which of the following changes of state occur?

_____ a. gases turn into solids
_____ b. gases turn into liquids
_____ c. liquids turn into gases
_____ d. liquids turn into solids
_____ e. all of the above

10. A thermostat works because it is made up of metals which expand

_____ a. at the same time.
_____ b. at different times.
_____ c. by the same amount.
_____ d. by different amounts.

Heat

ACHIEVEMENT TEST

Immediate Post-Test

WQED

Junior High School Science

Name _____ Grade _____ 7th or 8th

School _____

PART I: 9 minutes

Instructions: Answer the following questions in your own words.

1. What do we mean by a change of state?

2. After it was heated, the metal ball in one of the demonstrations wouldn't pass through the ring. Why?

3. You saw the balloon inflate when the flask of air was heated with the flame of the bunsen burner. What would happen to the balloon if the bunsen burner were removed? Explain why.

4. What was the main idea that was being illustrated by the demonstration of the bending bi-metal bar?

5. What changes of state occur when you cool objects off?

6. Describe what happens to molecules in liquids when liquids expand and contract.

PART II - FILL-INS: 6 minutes

Instructions: In the blanks below, fill in the word or words which makes the sentence correct and complete.

1. A _____ in the _____ of molecules will cause an object to contract.
2. At all temperatures molecules in solids are constantly _____.
3. If we remove _____ from a gas, the gas will turn into a _____.
4. The state of matter which contracts the least when cooled is a _____.
5. A bi-metal bar consists of _____ types of metals.
6. The state of matter which _____ the most when heated is a _____.
7. A _____ can be _____ _____ a solid by removing heat.
8. When heat is applied to objects, each object has its own _____ of _____.
9. A(n) _____ in the motion of _____ will cause an object to expand.
10. In one of the demonstrations you saw, the water rose in the tube when it was heated because the water in the flask _____.

Heat

Delayed Post-Test

ACHIEVEMENT TEST

WQED

Junior High School Science

Name _____ Grade _____ (7th or 8th)

School _____

PART I: 9 minutes

Instructions: Answer the following questions in your own words.

1. What happens to a bi-metal bar when it is heated? Explain why.

2. What was the main idea that was being illustrated in the demonstration you saw of the balloon attached to a flask of air?

3. After the heated metal ball was dipped in cold water, it could be passed through the ring. Explain why, describing what happened to the molecules in the metal bar.

4. What brings changes of state about? What do we mean by a change of state?

5. Describe what happens to molecules in liquids when liquids expand and contract.

6. Describe how solids, liquids, and gases are different in the way heat affects them.

PART II - FILL-INS: 6 minutes

Instructions: In the blanks below, fill in the word or words which makes the sentence correct and complete.

1. A _____ in the speed of molecules will cause an object to contract.
2. At all temperatures molecules in solids are constantly _____.
3. If we remove _____ from a gas, the gas will turn into a _____.
4. The state of matter which contracts the least when cooled is a _____.
5. A bi-metal bar consists of _____ types of metals.
6. The state of matter which _____ the most when heated is a gas.
7. A _____ can be _____ into a solid by removing heat.
8. When heat is applied to objects, each object has its own rate or amount of _____.
9. A(n) _____ in the motion of _____ will cause an object to expand.
10. In one of the demonstrations you saw, the water rose in the tube when it was heated because the water in the flask _____.

Nuclear Reactions ACHIEVEMENT TEST

Pre-Test

MQED

Junior High School Science Quiz

Form A

Name_____ Grade_____
7th or 8th

School_____

PART I: 4 minutes

Instructions: Answer the following questions in your own words. You will be allowed four (4) minutes. If you finish before this time please wait until I tell you to go on to the next part.

A. What particle is involved in a physical change and what happens to it?

B. What particle is involved in a nuclear change and what happens to it?

PART II - FILL-INS 7 minutes

Instructions: In the blanks below, fill in the word or words which make the sentence correct and complete.

Example: When water freezes it turns into _____.
(Write in your answer; if you wrote ice, you were correct.)

1a. Chemical changes are always accompanied by _____ changes.

2a. We can break a molecule of water into 2 atoms of _____ and one atom of _____. This is an example of a _____ change.

3a. A molecule of salt is made up of an atom of sodium and an atom of chlorine. This molecule weighs _____ the combined weight of the atom of sodium and the atom of chlorine.

4a. By means of nuclear changes we can make new _____.

5a. The amount of energy given off by fusion is _____ than the amount given off by a chemical reaction like oxidation.

6a. In a _____ change, 2 atoms may combine to form a new atom. This is an example of _____.

7a. In a physical change the _____ remain intact.

8a. In a chemical change _____ break up into _____.

9a. Chemical changes involve the _____ in the atoms.

10a. In a nuclear change _____ break up into _____.

PART III - MULTIPLE CHOICE ITEMS 4 minutes

Instructions: Each of the incomplete statements or questions below is followed by several possible answers. In the space provided put a check next to the answer you think is best.

Example: Water that is heated above the boiling point will turn into

_____ a solid.
__✓__ steam.
_____ ice.

11a. When heat is released, matter is being converted into energy

_____ some of the time.
_____ all of the time.
_____ none of the time.

12a. If two (2) units of H, each weighing 25 grams, undergo fusion to form one (1) unit of heavy hydrogen, the new atom would weigh approximately

_____ 25 grams.
_____ 49.85 grams.
_____ 50.00 grams.
_____ 50.15 grams.

13a. In chemical changes

_____ molecules break up into atoms.
_____ matter is converted into energy.
_____ weight of the atoms at the end weigh less than the atoms at the beginning.
_____ all of the above.

14a. When water undergoes a change of state; for example, when it freezes,

_____ the molecules break up into atoms.
_____ a large amount of energy is released.
_____ the ice weighs less than the original water.
_____ all of the above.
_____ none of the above.

15a. In physical changes

_____ molecules break up into atoms.
_____ molecules remain intact.
_____ atoms break up into nuclei.

16a. The weight of the atoms in the end product is less than the weight of the atoms in the beginning in

_____ physical changes.
_____ chemical changes.
_____ nuclear changes.
_____ all of the above.

17a. In nuclear changes

_____ atoms break up into nuclei.
_____ matter is converted into energy.
_____ the final product weighs less.
_____ all of the above.
_____ none of the above.

Nuclear Reactions ACHIEVEMENT TEST

Pre-Test

WQED

Junior High School Science Quiz

Form B

Name_____ Grade 7th or 8th

School_____

PART I: 4 minutes

Instructions: Answer the following questions in your own words. You will be allowed four (4) minutes. If you finish before this time please wait until I tell you to go on to the next part.

A. What particle is involved in a chemical change and what happens to it?

B. In what different forms can energy appear?

PART II: - FILL-INS 7 minutes

Instructions: In the blanks below, fill in the word or words which make the sentence correct and complete.

Example: When water freezes it turns into _____.
(Write in your answer; if you wrote ice, you are correct.)

1b. When hydrogen is burned, water is produced and _____ is released. This is an example of a _____ change.

2b. When water boils and undergoes a change of state, it turns into _____; this is an example of a _____ change.

3b. When matter is converted into energy, matter is _____.

4b. In chemical changes we make new _____.

5b. The amount of energy given off by a chemical reaction like oxidation is _____ than the amount that is given off by fusion.

6b. Fusion is an example of a _____ change.

7b. In a chemical change the _____ remain intact.

8b. In a _____ change molecules break up into _____.

9b. Nuclear reactions involve the _____ in the atoms.

10b. In a _____ change atoms break up into _____.

PART III MULTIPLE CHOICE ITEMS 4 minutes

Instructions: Each of the incomplete statements or questions below is followed by several possible answers. In the space provided put a check next to the answer you think is best.

Example: Water that is heated above the boiling point will turn into

____ a solid.
__✓__ steam.
____ ice.

11b. Matter is converted into energy in

_____ physical changes.
_____ chemical changes.
_____ nuclear changes.
_____ all of the above.

12b. If 50 grams of H and 400 grams of O combine to form water, the water would weigh approximately

_____ 350 grams.
_____ 425 grams.
_____ 450 grams.
_____ 475 grams.

13b. In physical changes

_____ a significant amount of energy is released.
_____ molecules remain intact.
_____ atoms break up into nuclei.
_____ all of the above.
_____ none of the above.

14b. In a chemical reaction such as the burning of hydrogen,

_____ water is produced.
_____ energy is released.
_____ atoms recombine to form a new product.
_____ there is no loss of weight involved.
_____ all of the above.

15b. In chemical changes

_____ molecules break up into atoms.
_____ molecules remain intact.
_____ atoms break up into nuclei.

16b. The weight of the atoms in the end product is the same as the weight of the atoms in the beginning in

_____ physical changes only.
_____ nuclear changes only.
_____ both physical and chemical changes.
_____ both chemical and nuclear changes.

17b. Destroyed matter can be changed into

_____ light energy only.
_____ heat energy only.
_____ both light and heat energy.
_____ neither light nor heat energy.

Nuclear Reactions

ACHIEVEMENT TEST

Post-Test

WQED

Junior High School Science Quiz

Form A

Name _____ Grade _____ (7th or 8th)

School _____

Did you watch Monday's program? ____ yes ____ no

PART I: 4 minutes

Instructions: Answer the following questions in your own words. You will be allowed four (4) minutes. If you finish before this time, wait until I tell you to go on to the next part.

A. What particle in matter is involved in a physical change? _____

What happens to this particle during a physical change?

B. What particle in matter is involved in a nuclear change? _____

What happens to this particle during a nuclear change?

PART II - FILL-INS 7 minutes

Instructions: In the blanks below, fill in the word or words which make the sentence correct and complete.

Example: When water freezes it turns into _____.
(Write in your answer; if you wrote ice, you are correct.)

1a. A release of _____ always accompanies a chemical _____.

2a. We can break a _____ of water into 2 atoms of hydrogen and one atom of oxygen. This is an example of a _____ change.

3a. A molecule of salt is made up of an atom of sodium and an atom of chlorine. This molecule weighs _____ the combined weight of the atom of sodium and the atom of chlorine.

4a. By means of nuclear changes we can make new _____.

5a. The amount of _____ given off by fusion is _____ than the amount given off by a chemical reaction like oxidation.

6a. When 2 atoms undergo _____ in a _____ change they combine to form a new atom.

7a. In a physical change the _____ remain intact.

8a. In a chemical change _____ break up into _____.

9a. Weight is lost in a _____ change. This indicates that _____ has been _____ into energy.

10a. In a nuclear change _____ break up into _____.

11a. The particle <u>in an atom</u> which is involved in a chemical change is the _____.

PART III - MULTIPLE CHOICE ITEMS 4 minutes

Instructions: Each of the incomplete statements or questions below is followed by several possible answers. In the space provided put a check next to the answer you think is best.

Example: Water that is heated above the boiling point will turn into

_____ a solid.
_____ steam.
_____ ice.

11a. When heat is released, matter is being converted into energy in

_____ physical changes.
_____ chemical changes.
_____ nuclear changes.
_____ all of the above.
_____ none of the above.

12a. If two units of H, each weighing 25 grams, undergo fusion to form one unit of heavy hydrogen, the new atom would weigh approximately

_____ 25 grams.
_____ 49.85 grams.
_____ 50.00 grams.
_____ 50.15 grams.

13a. In chemical changes

_____ molecules break up into atoms.
_____ matter is converted into energy.
_____ weight of the atoms at the end weigh less than the atoms at the beginning.
_____ atoms break up into particles.
_____ all of the above.

14a. When water undergoes a change of state, for example, when it freezes,

_____ molecules break up into atoms.
_____ a large amount of energy is released.
_____ the ice weighs less than the original water.
_____ all of the above.
_____ none of the above.

15a. In physical changes

_____ atoms recombine in new arrangements.
_____ molecules remain intact.
_____ atoms break up into nuclei.
_____ molecules break up into atoms.

16a. The weight of the atoms in the end product is less than the weight of the atoms in the beginning in

_____ physical changes.
_____ chemical changes.
_____ nuclear changes.
_____ all of the above.
_____ none of the above.

17a. In nuclear changes

_____ atoms break up into nuclei.
_____ matter is converted into energy.
_____ the final product weighs less.
_____ all of the above.
_____ none of the above.

18a. In your own words, tell us whether you found this lesson interesting. Why?

Nuclear Reactions

ACHIEVEMENT TEST

Post-Test

WQED

Junior High School Science Quiz

Form B

Name _____ Grade _____ (7th or 8th)

School _____

Did you watch Monday's program? ____ yes ____ no

7

PART I: 4 minutes

Instructions: Answer the following questions in your own words. You will be allowed four (4) minutes. If you finish before this time, wait until I tell you to go on to the next part.

A. What particle in matter is involved in a chemical change? _____

What happens to this particle during a chemical change?

B. What particle in matter is involved in a nuclear change? _____

What happens to this particle during a nuclear change?

PART II - FILL-INS 7 minutes

Instructions: In the blanks below, fill in the word or words which make the sentence correct and complete.

Example: When water freezes it turns into _____.
(Write in your answer; if you wrote ice, you are correct.)

1b. When hydrogen is burned, water is produced and _____ is released. This is an example of a _____ change.

2b. Changes of state are examples of _____ change.

3b. When matter is converted into energy, matter is _____.

4b. In chemical changes new _____ are formed.

5b. The amount of _____ given off by a chemical reaction like oxidation is _____ than the amount that is given off by fusion.

6b. Fusion is an example of a _____ change.

7b. In a chemical change _____ remain intact.

8b. In a _____ change molecules break up into _____.

9b. Nuclear reactions involve the _____ in the atoms.

10b. In a _____ change atoms break up into _____.

11b. The particle <u>in an atom</u> which is involved in a chemical change is the _____.

PART III - MULTIPLE CHOICE ITEMS 4 minutes

Instructions: Each of the incomplete statements or questions below is followed by several possible answers. In the space provided put a check next to the answer you think is best.

Example: Water that is heated above the boiling point will turn into

_____ a solid.
_____ steam.
_____ ice.

11b. Matter is converted into energy in

_____ physical changes.
_____ chemical changes.
_____ nuclear changes.
_____ all of the above.

12b. If 50 grams of H and 400 grams of O combine to form water, the water would weigh approximately

_____ 350 grams.
_____ 400 grams.
_____ 449 grams.
_____ 450 grams.
_____ 451 grams.

13b. In physical changes

_____ a significant amount of energy is released.
_____ molecules remain intact.
_____ atoms break up into nuclei.
_____ atoms recombine in new ways.
_____ none of the above.

14b. In a chemical reaction such as the burning of hydrogen,

_____ water is produced.
_____ energy is released.
_____ atoms recombine to form a new product.
_____ there is no loss of weight involved.
_____ all of the above.

15b. In chemical changes

_____ molecules remain intact.
_____ molecules break up into atoms.
_____ atoms break up into nuclei.
_____ nuclei interact.

16b. The weight of the atoms in the end product is the same as the weight of the atoms in the beginning in

_____ physical changes only.
_____ nuclear changes only.
_____ both physical and chemical changes.
_____ both chemical and nuclear changes.

17b. Destroyed matter can be changed into

_____ light energy only.
_____ heat energy only.
_____ both light and heat energy.
_____ neither light nor heat energy.

18b. In your own words, tell us whether this lesson was more or less interesting than the other science lessons you've been watching. Why?